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Paris Revisited

After an interval of six years, we returned to Paris to participate in the first post-war congress of the Association Technique de Fonderie. It was presided over by Prof. Chevenard, but following French custom, important people were asked to take the chair at the various sessions. The meeting was held in the lecture theatre of the "Maison de Fonderie," the headquarters of the French foundry employers' association. The hall was crowded at every session—a remarkable testimony of the anxiety of the French foundry technician to get himself up to date. By the way, it is neither easy nor comfortable to travel in the Paris area.

The first session opened with a speech by Prof. Portevin, who reviewed the present position of scientific research in foundry practice. He was obviously appreciative of the work done by Mr. Morough on the non-metallic inclusions in cast iron as revealed by modern micrographic technique. The only contribution to the discussion was made by the doyen of French metallurgists, Dr. Guillet, who had some interesting remarks to make on the beneficial influence of small percentages of indium on certain copper alloys. Then followed the presentation of the three international exchange Papers from America, the United Kingdom, and Belgium. Before each one, the chairman welcomed the delegate from the country concerned. This gave an opportunity for an expression of international goodwill from each. First, Mr. V. Delport, as European representative of the American Foundrymen's Association, presented greetings from that body, and invited representation at an international meeting to be held in the United States next year. He also brought a message from the (British) Council of Ironfoundry Associations, and its president, Mr. FitzHerbert Wright. Then followed the presentation of a Paper, "United States Wartime Developments in Cast Iron Foundry Practice," by Mr. J. S. Vanick, of the International Nickel Company. The British delegate, Mr. V. C. Faulkner, on being asked to address the congress, received a tumultuous ovation. He presented the good wishes for a successful congress from Mr. J. W. Gardom, the president of the Institute of British Foundrymen; Mr. T. Makemson, the honorary secretary of the International Committee; Mr. Geo. Hyslop; Mr. C. W. D. Townsend, and Mr. Cherry Paterson, respectively the presidents of the associations covering non-ferrous and steel foundry practice and foundry equipment. He then gave a *résumé* of some of the major developments which the British foundry industry had made during the war, and included the first public announcement of what may be popularly known as the "delayed action bomb method of feeding castings." M. Le Thomas then presented Mr. Baker's Paper on the "Control of Shrinkage Porosity in Castings," which was followed by the reading of the Belgian Exchange Paper by M. R. Deprez, the president of the sponsoring association. The subject was the "Martensitic Quench in Cast Irons," and the Author, M. G. Halbert, its secretary.

During the afternoon we took the opportuntiy to visit the laboratories of the "Centre Technique," centrally situated in the Avenue Victor Hugo. This organisation, directed by M. Le Thomas, is somewhat different from the E.C.I.R.A., as it covers all branches of foundry work. It is financed by the addition of half of 1 per cent. to all invoices sent out by the foundry industry. It has an excellent library, and will in the future publish its own magazine. It does not undertake pure research at the Avenue Victor Hugo, but finances its conduct at the universities and technical colleges. It does, however, undertake a vast quantity of development work. Typical of this is the testing of domestic

(*Continued overleaf, col.* 2.)

Contents

Paris Revisited, 171.—Forthcoming Events, 172.—Course in Foundry Technology, 172.—The Cause and Control of Microporosity in Magnesium Alloys, 173.—An Investigation on the Constitution of Certain Foundry Bonding Clays, 180.—German Steel Industry, 180.—A Discussion on the Gas Annealing of Whiteheart Malleable, 181.—Helping Apprentices to Choose Trade, 188.—News in Brief, 190.—Release of Factories, 190.—Personal, 192.—Obituary, 192.—Contracts Open, 192.—Examination in Foundry Practice and Patternmaking, 192.—Raw Material Markets, 194.—New Companies, 194.—No Purchase Tax on Stoves and Grates, 194.

FORTHCOMING EVENTS

(Secretaries are invited to send in notices of meetings, etc., for inclusion in this column.)

NOVEMBER 3.

Institute of Welding (Leeds branch):—"Fabrication Design for Machine Tools," by F. Koenigsberger. At the Technical College, Hoowood Lane, Halifax, at 3 p.m.

NOVEMBER 5.

Association of Bronze and Brass Founders:—Lancashire and Cheshire area meeting. At the Midland Hotel, Manchester, at 2.30 p.m.

NOVEMBER 7.

Scottish Engineering Students' Association:—"Photo Elasticity," by A. A. Wells. At the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, at 7.15 p.m.

NOVEMBER 8.

Institute of Welding (N.E. Tyneside branch):—"Welding as Used in Modern Electric Power Stations," by D. G. Sinfield. At the Mining Institute, Neville Hall, Newcastle-upon-Tyne, at 6.15 p.m.

NOVEMBER 9.

Institute of Welding (Birmingham branch):—"Review of the Application and Development of Oxygen Cutting," by R. Dore. At the James Watt Memorial Institute, Great Charles Street, Birmingham, at 6.30 p.m.

Institution of Mechanical Engineers:—"Elementary Principles of Plant Organisation and Maintenance for Civil Engineering Contractors," by H. O. Parrack. At Storey's Gate, St. James's Park, London, S.W.1, at 5.30 p.m.

NOVEMBER 12.

Association of Bronze and Brass Founders:—Yorkshire area meeting. At the Great Northern Hotel, Leeds, at 12.30 p.m.

NOVEMBER 13.

Institution of Chemical Engineers:—Joint meeting with the Chemical Engineering Group. "Some Practical Aspects of Large-scale Gas Distribution, with Particular Reference to Steelworks," by E. Hemingway Jones. At the Geological Society, Burlington House, Piccadilly, London, W.1, at 5.30 p.m.

NOVEMBER 15.

Association of Bronze and Brass Founders:—Midland area meeting. At the Station Hotel, Stoke-on-Trent, at 1 p.m.

Institute of British Foundrymen

NOVEMBER 3.

Lancashire branch:—"Production of Tank Wheels in a Mechanised Blackheart Malleable Foundry," by A. B. Bill and J. Peers. At the Engineers' Club, Albert Square, Manchester, at 3 p.m.

Wales and Monmouth branch:—Visit to Tubal Cain Foundry, Tyndall Street, Cardiff. Discussion of major problems associated with the jobbing ironfoundry opened by A. E. McRae Smith, at 2.30 p.m.

NOVEMBER 6.

Burnley section:—"The General Engineering Ironfoundry," by F. Gater. At the Municipal College, Ormerod Road, Burnley, at 7.30 p.m.

NOVEMBER 8.

East Anglian section:—"Symposium on Rate Fixing," by R. F. Coates, W. L. Hardy, F. E. Tibbenham and H. S. Ward. At the Lecture Hall, Central Library, Northgate Street, Ipswich, at 6.45 p.m.

NOVEMBER 10.

Lincoln section:—"Consistency and the Cupola," by C. A. Payne. At Lincoln Technical College, at 2.45 p.m.

Scottish branch:—Joint meeting with the Iron and Steel Institute. "The German Steel Foundry Industry," by Basil Gray. At the Royal Technical College, George Street, Glasgow, at 3 p.m.

COURSE IN FOUNDRY TECHNOLOGY

OPPORTUNITY FOR LONDON STUDENTS

A part-time course in foundry technology for the London area will commence on November 15, at the Borough Polytechnic, Borough Road, London, S.E.1, and potential students are asked to report to the Polytechnic at 9.50 a.m. on that day. Students 16 years and over will commence the first year of the course leading to the City and Guilds intermediate examination in foundry practice, and students under 16 years of age will take a preparatory course before entering the City and Guilds course. The times and subjects of these courses from November 22, inclusive, will be as follows:—Foundry course: 9.15-12.30, foundry technology and science; 1.30-4.30, calculations and drawing. Preparatory course: 9.0-12.15, calculations and drawing; 1.15-4.15, English and general science.

The Education Committees of Croydon, Essex, Kent, Middlesex and Surrey have intimated that they are prepared to pay any out-county surcharge. The Bucks Education Committee is prepared to consider each individual application which, it is understood, is their normal procedure.

Students may obtain a midday meal at the Polytechnic for 1s. 3d. With reference to travelling facilities, the Elephant and Castle tube station (both Northern and Bakerloo lines) or the Elephant and Castle bus stop for any appropriate bus route are about five minutes' and Waterloo and London Bridge stations are approximately 15 minutes' walking distance from the Polytechnic.

London foundry owners are invited to visit the students who will be taking this course, and it would be a great help to the Principal (Dr. Douglas H. Ingall) if intending visitors would possibly notify him in advance so that he could arrange to receive them at the Polytechnic.

Paris Revisited

(Continued from previous page.)

heating stoves. Before the war, the general order of these was, say, 35 per cent. efficiency. Now the law of the land demands 70-85 per cent. efficiency. The saving in the national fuel consumption will thereby run into millions of tons per annum. Moreover, M. Le Thomas has on his staff a number of technicians specially qualified to assist every type of foundry with every sort of help, including rebuilding and modernisation. His outlook is essentially directed towards the more inefficient, and he maintains that before real progress can be assured, this type of concern must re-learn the "catechism" of foundry practice. We were profoundly impressed with the general "set-up" which has been organised with the object of putting the French foundries into the front line of the progressive forces of modern industry.

THE CAUSE AND CONTROL OF MICROPOROSITY IN MAGNESIUM ALLOYS*

Comparative tests made on aluminium base alloys of similar constitution

By E. A. G. LIDDIARD, M.A., and W. A. BAKER, B.Sc.

(*Continued from page* 161.)

Mode of Solidification of Magnesium and Aluminium-base Alloys

The work described below was all carried out in an endeavour to correlate the way in which magnesium alloys solidify with the types of porosity found in them. At this stage it is worth while pointing out some essential differences between magnesium and other non-ferrous metals. Firstly, magnesium is by far the lightest of the commercially used metals, aluminium being the next. Magnesium differs from other commercially used metals, except zinc, in crystallising in the hexagonal system; most other metals are cubic. Another striking difference between magnesium and most other non-ferrous metals is in the low heat capacity of magnesium. Much less heat is required to melt a given volume of magnesium than any other metal because of the low specific heat and latent heat per unit volume. Magnesium will therefore solidify much more quickly than any other commercial metal when cast into the same mould. Figures showing the density and thermal properties per unit volume of magnesium as compared with other metals are given in Table I.

TABLE I.—*Thermal Properties per Unit Volume of Magnesium compared with other Metals.*

Metal.	Specific Gravity.	Mean Specific Heat.		Latent Heat of Fusion.
		Solid.	Liquid.	
		cal./cm.³/° C.		
Magnesium	1·8	0·50	0·54	90
Aluminium	2·7	0·68	0·70	250
Copper	8·9	0·89	1·06	440
Iron	7·8	1·25	1·34	500

1. *Alloys Tested and Types of Castings Used.*—A large variety of alloys were tested, including aluminium-base alloys as well as magnesium-base alloys. The alloys were chosen to have similar constitution and freezing range. All the types of castings described in the introductory section were used in this work.

2. *Methods of Modifying Solidification Rates.*—Magnesium-base alloys will, under comparable conditions of cooling, solidify much more rapidly than aluminium-base alloys. It became necessary therefore to find out what part this relatively rapid solidification rate played in determining the distribution of porosity. Castings of similar form in both magnesium and aluminium-base alloys were therefore cast in such a way as to give comparable solidification rates. For example, the rate of solidification of a metal can be delayed by using a high casting temperature. This results in excessive heat being introduced into the metal in the mould, and consequently the casting takes longer to solidify. One method used to lower the solidification rate of magnesium-base alloys was to use a high casting temperature. A small amount of calcium was, however, added to prevent

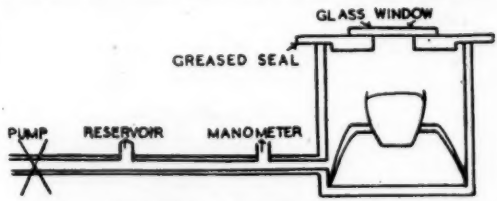


FIG. 8.—METHOD OF TESTING FOR THE PRESENCE OF GAS.

burning in alloys cast at high temperature; preliminary tests having shown that calcium additions had no significant effect in solidification behaviour or porosity.

Another method adopted was to pre-heat the mould before casting. This slowed down the rate at which heat was taken away from the metal by the mould and again resulted in a slower rate of solidification. The solidification rate of aluminium-base alloys was increased by introducing uniformly spaced chills into the mould.

3. *Measurement of Temperature Gradient during Solidification.*—In some of the test castings made, particularly those of vertical up-run bars (Fig. 1 (c)), thermocouples were placed at the top and bottom of the castings and records were taken of the temperature during their solidification. From these records curves were drawn showing temperature changes with

Microporosity in Magnesium Alloys

time. In most cases it was found that the temperature at the top of the bar was lower than at the bottom when the mould was first filled. As the metal solidified, however, the temperature difference between the top and bottom altered, and Figs. 10 and 11 are typical examples of the type of curve obtained.

When the temperature at the top of the casting was lower than at the bottom, as in the early stages of solidification of the casting to which Fig. 10 refers, solidification would proceed more rapidly at the top. In this case, the feeder head was at the top and during the early stages of solidification feeding from the feeder head downwards would be hindered.

The ideal temperature distribution would be that the top of the casting near the feeder was always hotter than the lower part, so that feeding proceeded downwards while solidification progresses upwards. By comparing the areas ABC in Fig. 10 with the areas CDE one can obtain an indication of the amount by which the temperature gradients during solidification of the casting were unfavourable. In the example given in Fig. 10 area ABC is about one-third of that of CDE, and the strength of the casting was only 50 per cent. of that of a fully fed DTD bar. In the casting to which Fig. 11 refers the temperature gradients were favourable during almost all the time that the casting was solidifying. In this case the strength of the casting was 84 per cent. of that of a fully fed DTD bar.

4. *Mechanical Tests.*—Test-pieces were cut from various sections (A, B, C and D) of the bar, as indicated in Fig. 1 (*c*) and also on a complete bar G. Density determinations were also made on the various sections of the bar.

5. *Results.*—When all the results were gathered together the following conclusions emerged:—

The total amount of porosity found in aluminium alloys judged by density was in every case more than that found in magnesium alloys under similar solidification conditions. The tensile strengths of castings which were not fully fed were about the same in both magnesium- and aluminium-base alloys, provided the conditions of solidification were similar. For a given amount of porosity as judged by density measurements the effect on the strength of magnesium alloys was greater than for aluminium alloys.

When bars in aluminium- and magnesium-base alloys were cast in greensand moulds of the same dimensions, it was found that the unfavourable heat distribution during solidification was very much greater in the case of magnesium alloys than in aluminium alloys, but when conditions of cooling were adjusted (either by pre-heating the mould or casting at a higher temperature for magnesium alloys or introducing chills into the sand for the aluminium alloys), the relative strength of the two materials was approximately the same. By relative strength is meant the

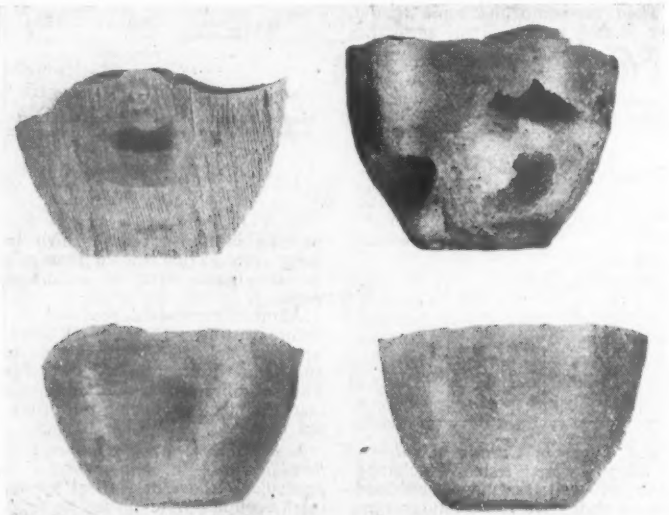


FIG. 9.—EXAMPLES OF INGOTS SOLIDIFIED UNDER REDUCED PRESSURE. × 1.

strength in the unfed castings as a percentage of the strength of fully fed DTD bars.

Typical figures are given in Table II, which includes a column headed "solidification factor" derived from curves as illustrated in Figs. 10 and 11. A high solidification factor means that during the major part of solidification the temperature gradients were favourable. The solidification factor is actually derived from the ratio of the amount of solidification that took place under a favourable temperature gradient to that taking place under an unfavourable gradient.

It will be seen that the loss in strength in the unfed castings depends essentially on the solidification factor, and that there is no real difference between provision must therefore be made for feeding these alloys than for most other non-ferrous metals.

Miscellaneous Experiments on Layer and Annular Porosity

In other work of the Association on inverse segregation it has been shown that porosity in the last portions of a casting to solidify is associated with the draining away of the last portions of liquid. Experiments were made to see whether there was a deficiency of the liquid which was last to solidify in porous parts of magnesium alloy castings. Analyses were carried out on samples drilled from porous patches in magnesium alloy castings and these porous patches were found to be deficient in the last solidi-

TABLE II.—*Correlation between Properties of Castings and Cooling Conditions in the Mould.*

Alloy.	Casting Conditions.			Solidification Factor.	Properties of Castings.								
					Porosity Voids Per Cent.				Relative Strength $\frac{UTS \times 100.}{UTS_{DTD}}$				
	Pouring Temp. deg. C.	Feeder/ Casting Ratio.	Mould Condition.		A.	B.	C.	D.	A.	B.	C.	D.	G.
93/7	740	1/1	Green	0·89	0·6	0·6	1·1	0·1	42	65	61	79	50
	740	1/1	Preheated*	9·4	0·7	0·4	0·4	0·0	73	86	79	98	76
Mg/Al	780	1·6/1	Green	2·8	0·6	0·3	0·8	0·1	70	74	64	77	62
	780	1·6/1	Preheated*	54	0·7	0·4	<0·1	0·0	77	75	77	89	84
95/5	770	1/1	Green	1·7	<0·1	0·1	0·3	0·1	109	75	51	102	50
	780	1/1	Preheated*	8·8	0·3	0·0	<0·1	0·1	100	81	84	98	73
Mg/Ni	800	1·6/1	Preheated*	15·5	0·4	0·0	0·0	0·1	100	88	86	97	80
93/7	770	0·5/1	Green	2·5	1·0	0·7	0·7	0·2	79	67	65	100	51
	770	1/1	Green	4	1·1	0·3	0·2	0·0	71	75	79	105	74
Al/Cu	780	1/1	80 gm. chill†	0·89	1·2	0·7	0·9	0·2	52	72	64	90	50
	780	1/1	120 „ „ †	0·92	1·0	0·4	1·4	0·5	63	74	40	67	34

* Mould face heated to 100 deg. C.

† Light chills of this total weight embedded along whole length of bar.

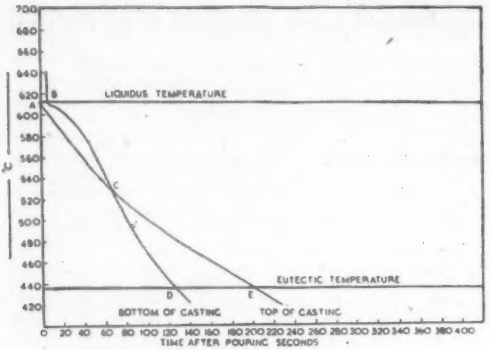
aluminium and magnesium alloys in this respect. This point is illustrated in Fig. 12, which shows the relation between solidification factor and minimum relative strength of up-run bars. This relation is independent of the composition of the alloy. There is, however, one point on which a difference persists. In the unfed magnesium alloy castings the porosity takes the form of layers of porosity or of intense concentrations of porosity; whereas in the aluminium alloys no layers of porosity were detected by X-rays, although intense concentrations of porosity were found. The most important conclusion from this work is that, owing to their low heat capacity, magnesium alloys solidify relatively fast in greensand moulds and that the temperature conditions tend to be less favourable to progressive feeding. Greater

fying liquid. In binary magnesium-aluminium alloys the last remaining liquid is higher in aluminium than the rest of the casting, and the analysis of the porous region shows deficiency in aluminium content. It follows, therefore, that some of the liquid has drained away during the last stages of solidification. This was further proved by adding a small amount of copper to the alloy, since this copper is also associated with the last portions of the alloy to solidify. Again, a deficiency in copper was found in the porous regions. In this respect also, therefore, magnesium alloys behave similarly to other alloys.

Some castings were also made in magnesium-base alloys to which beryllium was added. Beryllium has the effect of increasing the grain size very considerably until it approximates to that of a coarse-grained

Microporosity in Magnesium Alloys

aluminium casting with grain dimensions of the order of 3 to 4 mm. as compared with about 0.1 mm. for beryllium-free metal. In these alloys a striking change was observed in the distribution of porosity, which tended to concentrate towards the centre of the casting, the patches of porosity having roughly equal dimensions in three directions at right angles, with no layers of porosity such as were found in castings of the same form in a fine-grained material. It



POSITION OF TEST-BAR. SEE FIG. 1 (*c*).

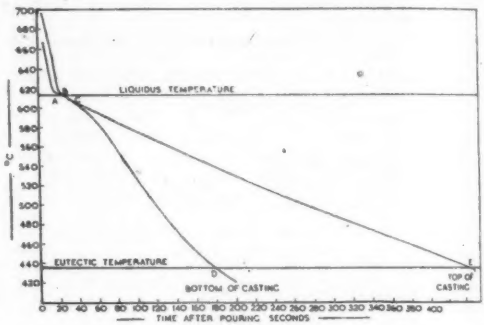
	A.	B.	C.	D.	G.
Voids, per cent.	0.6	0.6	1.1	0.1	—
$\frac{UTS \times 100}{UTS_{DTD}}$	42	65	61	79	50

FIG. 10.—TEMPERATURE DISTRIBUTION DURING SOLIDIFICATION AND MECHANICAL PROPERTIES OF TEST-BARS IN 93/7 MG-AL TOP-FED CASTING POURED AT 740 DEG. C. INTO GREENSAND MOULD. FEEDER/CASTING RATIO 1/1.

follows that the small grain size of the magnesium alloys is a factor contributing to the formation of layer porosity.

Some experiments were also carried out with chill-cast bars. With cylindrical-cast bars a ring of porosity is found at a distance from the chill face. It was found very difficult to control this annular porosity in chill castings and to obtain reproducible results with castings solidified under apparently identical conditions. To control the solidification conditions more precisely the molten metal was held in cylindrical iron containers which were at the same temperature as the metal, and these were then lowered into baths of solder maintained at a constant temperature. It was hoped in this way to control the conditions of freezing exactly, and to be able to reproduce the annular type of porosity at will. It was shown that fine-grained material tended to form annular porosity, but coarse-grained beryllium containing material showed central shrinkage. Marked annular porosity was not, however, always found in fine-grained material, and some other factor may operate which makes it difficult invariably to reproduce annular porosity in such material even with this close control of solidification conditions.

That annular and lake porosity are essentially similar and arise from the same cause was proved by a sand-cast bar poured unusually cold, which showed annular porosity in that part of the bar where the metal could freeze most rapidly, merging



POSITION OF TEST-BAR. SEE FIG. 1 (*c*).

	A.	B.	C.	D.	G.
Voids, per cent.	0.7	0.4	<0.1	0.0	—
$\frac{UTS \times 100}{UTS_{DTD}}$	77	75	77	89	84

FIG. 11.—TEMPERATURE DISTRIBUTION DURING SOLIDIFICATION AND MECHANICAL PROPERTIES OF TEST-BARS IN 93/7 MG-AL TOP-FED CASTING POURED AT 780 DEG. C. INTO MOULD HEATED TO APPROX. 100 DEG. C. FEEDER/CASTING RATIO 1.6/1.

into the normal layer type further along the bar. In the intermediate region the porosity took the form of a series of small layers normal to the mould wall, but arranged in an annulus.

Experiments with magnesium-zinc (7 per cent.) alloys showed that these alloys were moderately fine grained and contained layers of porosity similar to those described previously except that the layers were deeper. In certain castings there were layers of eutectic similar in form to the layers of porosity and this is illustrated in Fig. 14.

The Mechanism of Microporosity in Magnesium Alloys

Much of the mystery that has hitherto surrounded the occurrence of microporosity in magnesium alloys disappears with the findings (*a*) that under comparable conditions of solidification the strength of unfed

castings in both magnesium and aluminium alloys is affected to the same extent, and (*b*) that it is more difficult to ensure correct solidification conditions in magnesium than in aluminium alloys. It is proved that microporous areas in both magnesium and aluminium alloys are deficient in the last liquid to solidify, and that the porosity is therefore essentially due to shrinkage. Some differences between the two materials still remain for explanation, which must be somewhat speculative; these are as follow:—

(1) Under the same solidification conditions magnesium alloys show by density measurements less overall porosity than aluminium alloys.

(2) For a given amount of porosity judged by density measurements the strength of magnesium alloys is more seriously affected than that of aluminium alloys.

(3) Gas in aluminium alloys may alter the form and/or distribution of porosity in an unfed casting, so that in some cases the strength is actually improved. In magnesium alloys gas does not affect the form of porosity, and no tendency to give a more uniform distribution of porosity or to improve the strength has been observed in this work.

(4) Porosity in fine-grained magnesium alloy takes the characteristic layer form in sand castings and frequently appears as an annulus in cylindrical chill castings.

These observations may be largely explained by the form of the dendrites in cast magnesium alloys. The dendrites in magnesium alloys form small rosettes with six main branches on one plane and with little if any growth at right angles. Typical dendrites in magnesium alloys are shown in Fig. 13. In metals which solidify in the cubic system the dendrites tend to grow equally in three directions at right-angles parallel to the faces of the cube. It is reasonable to assume that there is less likelihood of interlocking of the hexagonal dendrites as compared with cubic dendrites, since the former tend to grow in one plane and there is less chance of residual liquid being trapped and forming shrinkage or gas voids between the branches of the hexagonal dendrites. Any shrinkage of liquid so trapped between the branches of the hexagonal dendrites is fed from one side or the other of the flat hexagonal plate. Hence, the overall soundness of magnesium alloys is greater, judged by density determinations, than that of cubic metals.

An added factor which is likely to contribute to the overall soundness of most cast magnesium alloys is their fine grain as compared with most aluminium alloys. A fine-grained material is more likely to feed with movement of the pasty mass of small crystals and liquid than a coarse-grained material where the large dendrites would tend to hinder mass movement. If, as is suggested, the unsoundness in magnesium alloys will tend to concentrate at the outside of the hexagonal dendrites, whereas in cubic metals a large proportion may be trapped between the dendrite branches, it would follow that any unsoundness caused either by shrinkage or gas would have a more serious effect on the strength of hexagonal metals.

The occurrence of layers of porosity in magnesium alloys has been shown to be associated with the fine grain of properly melted metal. Coarse-grained metal does not show layers. It seems probable that these layers form at a late stage in freezing, while a pasty mass of small crystals and liquid is moving to compensate from shrinkage. Apparently local "faults" develop in this mass at right-angles to its direction of movement and are pulled farthest apart at the centre of a sand-cast bar where the movement is greatest. This mechanism is suggested by the observation on magnesium-zinc alloys where it was found (see Fig. 14) that the layers of porosity were in some cases associated with layers of low melting point liquid.

It seems likely that the faults developed in the moving mass of crystals may in some cases be healed

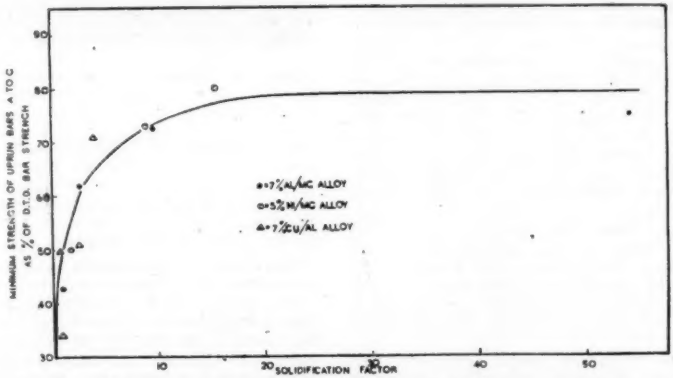


FIG. 12.—EFFECT OF SOLIDIFICATION FACTOR ON MINIMUM STRENGTH OF UP-RUN BARS.

Microporosity in Magnesium Alloys

by influx of low melting point residual liquid and the resulting pool act as a local feeder at a later stage in freezing, the liquid draining away from this pool to feed freezing shrinkage in the adjoining metal. In other cases the faults may form at a later stage in freezing and may never then be healed. In the case of chill castings the sound outer zone probably represents material which has solidified rapidly from the mould walls inwards, and in the central, slightly unsound portion, mass feeding of small crystals and liquid has taken place. In this case the faults develop between the two zones. It should be remembered that the degree of porosity may be influenced by small variations in gas content below the limits detectable by the test used.

The Technique of Casting Magnesium Alloys

The most striking conclusion from the work described above is that there is no essential difference between aluminium- and magnesium-base alloys in respect of loss of strength in unfed castings when the castings solidify at the same rate and under the same conditions of temperature distribution. When a particular casting in a gas-free magnesium-base alloy shows a relatively greater loss of strength in unfed portions than would a gas-free aluminium alloy, this is because the magnesium alloy solidified much more rapidly than the aluminium alloy would, and the temperature conditions during solidification have therefore been less favourable.

The mechanism of microporosity in magnesium-base alloys is essentially similar to that of any other non-ferrous metal, and is due to the draining away of the last portions of the metal to solidify from parts of the casting which cannot be properly fed. Owing to the more rapid rate of solidification of magnesium alloys under similar conditions, they are more sensitive to bad temperature distribution in the mould. It follows that the casting technique must be adjusted to ensure the best solidification conditions and proper feeding. In practice most magnesium alloy castings are bottom or middle run, and the metal is seldom poured direct into the mould through the cavity which is subsequently to act as a feeder. This is because of the danger of trapping oxide and flux in the casting if the metal flows in a turbulent broken stream into the mould. Such inclusions can seriously weaken the casting and make it highly susceptible to corrosion. At the same time, the necessity for bottom or middle running increases the difficulty of obtaining good temperature conditions in the mould, since, with top feeders, the metal which eventually reaches them is cooled as it runs through the mould and is cooler than the metal coming in at the bottom of the casting.

The experiments described below illustrate this point and show the advantage of putting feeders at the bottom instead of the top of the casting, since gravity is shown to play a minor part in feeding, at least in the last stages of freezing.

1. *Experimental Work.*—Most of the work on various methods of running magnesium alloy castings was done on magnesium 7 per cent. aluminium alloy, but some tests were made on the proprietary alloys, AZ31 (3 per cent. Al, 1.5 per cent. Zn, 0.3 per cent. Mn) and A8 (8.5 per cent. Al, 0.5 per cent. Zn, 0.3 per cent. Mn).

The castings used were:—(A) Top-poured bars. Fig. 1 (*b*); (B) "Conventional" bars, *i.e.*, bottom-poured with feeders at the top. Fig. 1 (*c*); and (C) Bottom-run bottom-fed bars. (Fig. 1 (*d*).)

2. *Results.*—The advantages of a top-poured bar have been shown throughout the work of this research by the consistently high strength of the top-poured DTD bars. These bars can be poured on the slope to avoid inclusions. The hot metal runs through the feeder cavity, heating it up, so that the best temperature gradient is set up while the bar is solidifying. As the length of the bar increases it becomes more difficult to avoid inclusions and for the feeder at the top of the bar to do its job. Strengths approaching those of DTD bars were found using a very slow rate of pour with the bar tilted. The use of a slow pouring speed introduces one difficulty: the metal in the pot loses heat rapidly, and by the time the bar is filled the metal in the feeder head may be too cold to feed properly.

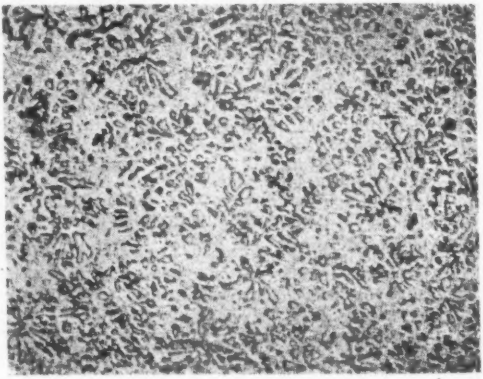


FIG. 13.—DENDRITES IN SAND-CAST 93/7 MG-AL ALLOY. × 30.

The most striking result was, however, found on comparing the strengths of the "conventional" and "bottom-fed" bars. Averaging all the results, and taking the strength of the DTD bars as 100 per cent., the strength of the bottom-fed bars was 84 per cent. compared with 62 per cent. for the "conventional" bottom-run top-fed bars. *The cross section of the downgate must, of course, be large enough to maintain pressure of the liquid metal on the bottom feeder until a coherent skin forms round the casting proper.*

and if this be done, gravity plays little part in the final stages of solidification and feeding.

The experiments described below illustrate this that the incoming metal passes through the feeder cavity and heats it up and comparatively cold metal reaches the top of the bar. The temperature gradient during solidification is, in this case, from bottom (feeder cavity) to top. The best results were found when the pouring speed was low enough to allow the metal to solidify just as the top of the bar was reached. With high pouring speeds the metal reaching the top of the bar was hotter and a less steep temperature gradient was set up. In heavy section castings, in which the metal remains molten for a longer time, the possibility of convection currents causing the hotter metal to rise should also be kept in mind.

Application to Foundry Technique

Although the results outlined above are of considerable practical importance, they only show general principles. The castings made in magnesium alloys are much more complicated than the simple bars used in the laboratory, and it is seldom possible to run and feed a casting employing bottom runners and feeders only. In many cases it may be possible to get similar good conditions by middle running with the feeders at the ingates on the parting line. There are also other ways of obtaining correct freezing conditions; for example, the side-running technique, in which the metal is admitted to the mould cavity by a side slit runner, or the use of a cross runner near the top of the mould, so that metal direct from the pot runs through it when the mould is nearly full and fills the top-feeder head with hot metal.

It is not possible to lay down hard-and-fast rules for good magnesium foundry practice, since the casting technique depends so much on the particular casting, but the following points should be observed.

1. See that the metal is free from gas. This can best be done by using clean dry metal that has not corroded on storage. If the metal has corroded, remove corrosion products by scratch brushing and preheat the metal out of contact with furnace gases, which usually contain much moisture. Test the melt by taking a small sample and allowing it to solidify under reduced pressure as described earlier in this Paper. If the metal is gassy, allow it to solidify in the pot and remelt. The extra fuel involved is unimportant compared with the waste caused by porous castings.

2. Adjust the running and pouring conditions to ensure that the temperature conditions during solidification are such that the important parts of the casting solidify first and that the feeders are full of hot metal. The ideal sought is uniform progressive solidification in one direction from those parts of the castings remote from the risers to the risers.

Remember:—(*a*) That magnesium alloys will lose heat quicker than any other commercial alloys when running through the mould; (*b*) that feeder cavities can be preheated either by external heating (*e.g.*, with a gas flame) or by allowing hot metal to pass through them; (*c*) that feeder cavities need not necessarily be at the top of the casting since, provided the downgate is of sufficient cross section, gravity is relatively unimportant in feeding, and hot metal will easily feed upwards to parts of the casting where the metal is partly solid; (*d*) that in the important parts of a casting the metal should remain as quiet as possible. Wherever a large volume of metal passes a particular point the sand becomes overheated. The metal at that point will remain molten longer and will feed nearby parts and when it finally solidifies will contain shrinkage cracks or cavities. There is the added danger of gas pick-up by reaction with the overheated sand, and (*e*) that dross and flux inclusions must be minimised by pouring as quietly as possible, and by the proper use of pouring basins and flux traps.

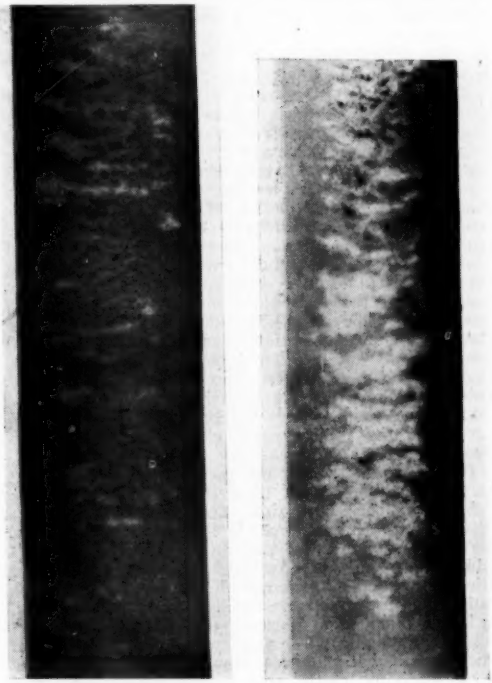


FIG. 14.—RADIOGRAPHS OF 93/7 MG-ZN ALLOY BARS. IN THIS POSITIVE PRINT THE WHITE STREAKS DENOTE PATCHES OF POROSITY AND THE DARK ONES INDICATE PATCHES OF EUTECTIC. THE FEEDER/CASTING RATIO WAS 3/1 FOR THE SPECIMEN ON THE LEFT AND 1/1 FOR THAT ON THE RIGHT. NOTE MANY DARK AND FEW WHITE STREAKS IN THE LEFT-HAND PICTURE AND THE REVERSE IN THE RIGHT-HAND ONE. × 1.

AN INVESTIGATION OF THE CONSTITUTION OF CERTAIN FOUNDRY BONDING CLAYS

By R. W. GRIMSHAW, B.Sc., and A. L. ROBERTS, Ph.D.

Below we print a written contribution, together with the Authors' reply, to the discussion on a Paper read at the annual meeting of the Institute of British Foundrymen.

MR. W. H. SALMON wrote:—The Authors are to be congratulated on introducing to the notice of foundry technicians a method which may prove of the utmost importance in the selection of the best types of clay for different purposes. Have the Authors any indication that they obtain the same type of curve from a mineral powder irrespective of its grain or particle size? It would be interesting if they would include curves for three different grades of pure silica and alumina. Have the Authors any reason for not drying the samples to remove the hygroscopic water before carrying out the differential thermal analysis? It is possible that the large absorption of heat to remove the hygroscopic moisture, extending from 50 to 300 deg. C., may mask other important indications, for example, the thermal effect shown by the presence of unhydrated Fe_2O_3 on Curve B in Fig. 1.

Can the Authors show differential thermal analysis curves for the Fullers' earth clays now employed in steelfoundries as substitutes for bentonite?

Replying to Mr. Salmon, the AUTHORS stated that in their experience the thermal effects in clay were independent of particle size. This point was fully discussed in their recent Paper in the June, 1945, issue of the British Ceramic Society. In all quantitative determinations of mineral content, the test-samples were dried at 120 deg. C. to remove hygroscopic water. This had not been done in the samples shown in the Paper, as it was intended to illustrate the difference in water-adsorption of the different clays under consideration. They agreed that a large amount of hygroscopic water would probably mask other thermal effects occurring at low temperatures.

The Authors had examined certain Fullers' earth clays used in foundry practice and had found them to contain minerals of the montmorillonite type. The thermal curves were especially interesting in that they showed anomalous features which still needed interpretation, as well as indications of considerable amounts of impurity (*e.g.*, $CaCo_3$). They hoped to deal with the thermal analysis of such materials later.

They could not very well show thermal curves for different grades of silica and alumina at the moment. Crystalline silica (*e.g.*, quartz) gave only a small thermal effect corresponding to the inversion at 575 deg. C., and very sensitive apparatus was needed to measure it. In the course of other work, however, they had developed such a method, which was being used for the determination of the quartz content of clays. Thermal effects in alumina were confined to the hydrated forms and were absent from calcined material. Curves for the mono- and trihydrates were shown in the Ceramic Society Papers mentioned previously.

GERMAN STEEL INDUSTRY

WORKING ON BEHALF OF THE ALLIES

The Ruhr iron and steel industry is now beginning to operate again on behalf of the Allies, and several works, including the Gutehoffnungshütte of Oberhausen and Sterkrade, and the Dortmunder-Hoerde Huttenverein, have been instructed to restart their rolling mills. The small quantity so far produced has been used entirely for local needs—bridge repairs, house construction, etc. Coal, transport and labour are the limiting factors.

Although no official announcement has yet been made, reports state that Germany may be allowed a finished steel production equivalent to 50 per cent. of her pre-war annual consumption, with a corresponding output of metallurgical coke. Of the ingot producing capacity of Germany proper, 70 per cent. is in the British zone, and, of this, it is reported that 5,000,000 tons is in fit condition to be put into operation immediately, with the possibility of doubling this figure in about three months. No decision yet appears to have been made as to which industrial plants are to be dismantled and shipped to Allied countries.

Reports indicate that a surprisingly large amount of iron- and steel-making plant was found to be intact or little damaged in the Ruhr. Even in Essen, where structural damage was greatest, a considerable amount of plant is claimed to be still usable, while here and there whole works are virtually unscathed. Recent estimates claim that 50 to 60 per cent. of the Ruhr capacity could be got working again in a reasonable time.

Effects of Bombing

At the end of January, 1945, Armaments Minister Speer estimated his total possible Ruhr steel production at only 300,000 tons monthly, or less than one-third of the equivalent 1943 output. Damage to power, gas and water supplies, combined with dislocation of transport, brought production to a standstill even in works which had escaped bombing. Apart from labour, the one general bottleneck in production was transport. The strain of military traffic was enormous, and the rail and canal facilities had not been expanded to anything like the degree needed to cope with the increased industrial production. The "scorched earth" policy outlined by Speer to the Ruhr industrialists in October, 1944, was never carried out.

Dispersal of plants is reported to have worked out far better than was expected. Production in dispersed plants rarely came up to that in the old plants, but deficiencies were more than made up by expansion of facilities at dispersal points. Shortage of raw materials did not adversely affect war production, acute shortages of specific materials being usually foreseen and forestalled in the laboratories. If supplies of iron ore from Sweden had been cut earlier, however, it might have been a different matter. Iron-ore stocks in September, 1944, were generally very much lower than in September, 1943.

A DISCUSSION ON THE GAS ANNEALING OF WHITEHEART MALLEABLE

Potential revolution in the historic processes examined by leading authorities

The following is a report of the joint discussion on two Papers, "Production of Whiteheart Malleable Iron by Annealing in Partially Burnt Town's Gas," by I. Jenkins, M.Sc., and S. V. Williams, B.Sc., and "The Annealing of Whiteheart Malleable Iron by a Gaseous Process," by A. G. Robiette, M.Sc., which were read at the annual meeting of the Institute of British Foundrymen. The former was printed in our issues of October 4 and 11, and the latter in our issues of July 26, August 2 and August 9.

High Temperature and Decarbonisation

MR. A. E. PEACE, after congratulating the Institute on having two such excellent Papers presented to it, said it was quite interesting to find that two Papers on such an important subject should be complementary to one another. The Paper by Jenkins and Williams dealt with the fundamental principles, and that by Robiette dealt extensively with the practical applications.

Commenting on the first Paper, he said he considered the curves in Fig. 5 and the comments upon it which followed exaggerated the significance of the amount of decarburisation at the higher temperature. The differences in carbon content in a reasonable time for varying temperatures were not commercially important and the figures in the Paper were not, in his view, commercially important, although the structural distribution might very well be so. Unfortunately, the Authors only illustrated this structural distribution for two temperatures and one sectional thickness, and he suggested that the value of future work would be enhanced if the carbon gradient from the edge to the centre was determined, showing both combined and free carbon. The Authors referred to the decrease in the carbon nodules with the higher temperature. This, of course, was due to the increased carbon solubility in the austenite. High temperature annealing was used by A. A. Timmins and himself some years ago to prevent undesired blackheart type of structure being produced in a whiteheart malleable which was not of a satisfactory composition.

Could the Authors offer an explanation of the apparent inconsistency in their Fig. 6, where for 20 hrs. at 1,000 deg. C., there was more ferrite than for 20 hrs. at 1,050 deg. C., and yet for 40 hrs. this condition was reversed. With regard to Fig. 7, he could not understand how the curves showed that a given residual carbon content was obtained in a shorter anneal in gas than in hematite ore. He did not dispute it as a fact, but he did not see anything in the curves which revealed it. Whilst this work was essentially fundamental, malleable producers would be considering the application of it, but they could not proceed far without some knowledge of the physical properties obtained with the gas-annealed material.

Possibility of Gas Stagnation

The Paper by Mr. Robiette dealt very comprehensively with the application of the gaseous process, and the information concerning the austenitic malleable irons was particularly interesting. Manganese steel castings were usually in very heavy sections, and he wondered what had been the effect of decarburisation on much heavier sections than those mentioned in the Paper, where the manganese-sulphur ratio might have a very different effect upon graphitisation.

Continuing, Mr. Peace said that in trying to correlate some of the data in the two Papers there were some difficulties. For instance, Mr. Robiette in his Table II gave a time of 36 hrs. at 1,050 deg. C. for annealing ¼-in. section to a carbon content of something below 0.5 per cent., whereas the Jenkins and Williams Table I showed for a similar section and temperature a residual carbon of 0.87 per cent. at 30 hrs., and 0.74 per cent. at 40 hrs. Slightly different cast conditions were used, but he would be interested to hear the views of the Authors on this matter.

In commercial work, it was a point of some concern to know how small castings which would pack together to produce the minimum size voids, would be swept by the annealing atmosphere. Where the interstices were exceedingly small, it was possible to visualise extremely low velocities, and there might even be actual stagnation. Had any difficulties been encountered in this connection, and, if so, what was the method of overcoming them.

He was also interested in the economies of the process, although he did not think that these were by any means the only factors which recommended it. But he wondered how the position would work out where production was large and large-scale annealing had to be carried out. In general, as oven capacity was increased, costs were reduced, but in the case of large-capacity furnaces of the type necessary for gaseous annealing, he imagined there was a very high capital cost and possibly some difficulties with operation due to the very much increased size. It seemed to him that to be economically useful for very large outputs, the continuous treatment process should be adopted, and he would like Mr. Robiette's view on the use of the continuous furnace under these conditions.

Practice Compressed

MR. F. K. NEATH, B.Sc., expressed appreciation that the problem of decarburisation had at last been placed upon a scientific basis. It was a subject which had been written about and talked about and largely guessed about for many years, and to get two Papers like these in such close agreement was a great satisfaction. This was more particularly the case because the work dealt with had been corroborated by some German work

Gas Annealing of Whiteheart Malleable

during the last few years, the results of which had been translated by the Iron and Steel Institute. There was one crumb of comfort to those in the industry who had used the iron-ore annealing process for many years, and that was that the results in these two Papers, and also the German work, showed that the atmosphere in an ordinary annealing pot usually consisted of 70 per cent. CO and 30 per cent. CO_2. That was the result of tests actually taken from annealing pots during the course of an anneal, and it indicated that the iron-ore process gave just the right gas composition! At all events, it showed that practical experience was not so very far behind in one respect. The processes described in these Papers were getting to the stage of practical possibility largely due to the improvement in furnace design and technique during the last 15 years, although 25 or 30 years ago furnace design in this country was not as good as it might be.

He himself, like so many other of the younger members of the Institute, was under a debt which could never possibly be repaid to one of their past-presidents, Mr. F. J. Cook. He well remembered a trip he had with Mr. Cook some years ago which took them out into the Black Country. Here a Mond gas plant was in operation annealing whiteheart malleable castings in a gas atmosphere. The foundry was using a furnace which was good for those days, although it would not be considered so satisfactory to-day. It was a muffle type of furnace, and the work was being done on a commercial basis. This Mond gas was being used straight from the producer plant, and the composition of that gas then—and possibly now—was richer than the gases utilised by the Authors. It consisted of 25 per cent. hydrogen, 18 per cent. CO, and probably 13 to 14 per cent. of CO_2. The ratios were very similar to those which the Authors had shown to be good for the decarburisation process.

Experiments with Ammonia

As a matter of fact, he himself had carried out some similar experiments about eight years ago. He had been talking to a chemical engineer dealing with the preparation of gases for bright annealing of steel and given him a few pounds of castings and asked him to try them. The results were quite successful as judged by the ordinary rough and ready destructive bending tests of the malleable-iron founder. This particular firm were not furnace people. They used ammonia passed through a burner. He believed they called it wet regenerative ammonia burner gas. In actual fact, it contained between 5 and 10 per cent of hydrogen with nitrogen and traces of water vapour, and the temperatures and times and results were similar to those which were mentioned in these Papers.

Mr. Neath said he had done a few tests himself in a laboratory furnace with hydrogen and obtained somewhat similar results, but possibly with not quite the speed obtained with the mixed gases which had been referred to. This, of course, was history, but he mentiond it to show that really the process had been coming along slowly for a long time and a stage had now been reached when it could be regarded as a practical proposition. Strangely enough, when he left home to come to this meeting the postman handed him a large envelope from America containing the new issue of the "American Foundryman," and looking at it in the train he saw an advertisement for a radiant tube gas-furnace for annealing American malleable in a self-generated gas atmosphere. That was a gas-tight furnace and was near to what Mr. Robiette had been talking about. Perhaps Mr. Robiette would be able to confirm that if the furnace was sealed to prevent any gas leakage, the amount of carbon removed from the blackheart castings would be infinitesimal.

He agreed with Mr. Robiette's remarks about test-bars and the attempt that was being made to get these on to a better basis. With regard to the heat-treated whiteheart a quantity of malleable of tolerable section was now being used for welding purposes and the suggestion made by Mr. Robiette might not be so applicable in these cases because in welding it was necessary to remove the carbon as completely as was practicable in the recognised whiteheart metal.

In conclusion Mr. Neath said he hoped that the results of this work would now be applied in a real practical way in the industry and so obtain data which would, no doubt, result in the Authors being provided with other problems in a year or two.

Gas Annealing and Peeling

MR. J. BERNSTEIN, expressing his special interest in the theoretical considerations of this subject, said there were one or two points on which he would like a little enlightenment. In the Paper by Jenkins and Williams it was stated that, after the annealing had been carried on for the requisite period, the stream of gas was cut off and a positive pressure was maintained. He would like to know how the positive pressure was maintained or whether it was assumed that the pressure was still positive after cooling down. Was any used gas or air drawn in during the contraction of the gases during the cooling period? It was also mentioned in the same Paper that test-pieces were put in the furnace when the latter was at temperature. Had the experiment been tried of putting the test-pieces in the furnace when cold and taking them through a complete annealing cycle for comparison with standard annealing practice?

In connection with Mr. Robiette's Paper, he said the statement was made that peeling was impossible in the gaseous process, but he thought Mr. Robiette would agree that it was possible; therefore, it was felt that that statement should be qualified by the addition of the words "in the absence of sulphurous gases." He asked all three Authors whether they had noticed any effect due to the residual sulphur in the gases they were using. It was known that the gas companies removed a fair amount of sulphur, but he would like to know whether the gas, after passing through the furnace, showed a higher or lower sulphur content than on entering the furnace. Had any experiments been made with regard to this?

A further point in connection with Mr. Robiette's Paper was that, when the castings were assembled and the surface of adjacent castings came into contact, was there any difference in the amount of decarburisation at the points of contact? Mr. Peace had mentioned the possible stagnation of gases in voids between the castings, and that had some relation to the relative stability of the equilibrium of the gases and to the edges of adjacent castings not exposed to the gas.

Lack of Co-operation

MR. DOVEY said that Mr. Williams was disappointed that he could not be present, and he himself had promised to make one or two remarks on his behalf. It seemed remarkable that two firms who were outside the industry should put forward these two Papers simultaneously on a new technique. In wartime information did not get around quite so quickly as in peacetime, but there did not seem to be the co-operation there might be among those interested in the application of gaseous atmospheres. Therefore, such facilities as his organisation possessed for research and development were available to everyone interested in investigating problems arising in heat-treatment and the application of this gaseous annealing. Mr. Robiette had pointed out that it was possible to decarburise and recarburise in a gaseous atmosphere, and, of course, all the tricks of the gaseous process could be used in this application. Mr. Robiette was asked for information as to the cost of the process and the cost of the element replacements, and whether the temperature of 1,050 deg. C. was really the optimum temperature, despite the fact that the value of the diffusion constant was high at this temperature.

Speaking on his own account, Mr. Dovey referred to castings ¼ in. thick or less which were packed very closely and suggested that, theoretically at any rate, it would be an advantage to use a gas in which there was no appreciable concentration of inert nitrogen at the start of the process. With all types of fairly small castings, the treatment usually took only a very short time and the effect of using a highly decarburising atmosphere would be felt more with thin section work. As regards warping, in the case of intricate castings and high temperatures, had Mr. Robiette run into any trouble in that respect, and with regard to the gas flow over densely packed small castings, was the treatment uniform?

Referring to the appendix to Mr. Robiette's Paper, he asked if the figure of 16.3 was correct, and on what grounds did Mr. Robiette say that CO_2 was probably the most important decarburising agent? There was a statement as to the concentrations of gases which arose from certain initial percentages of hydrogen and water vapour; did these figures agree with the preceding expression for the equilibrium constant and, if so, were they compatible with the initial percentages given? Furthermore, was the expression for the equilibrium constant for equation (3) which included the term $\frac{Nc}{NFe}$ correct?

Sulphur-manganese Balance and Coarse Graphite

MR. H. G. HALL said that those engaged in the malleable industry should be very grateful to the Authors of these two Papers and added that personally he felt we were on the edge of a new era, the application of science to the manufacture of malleable cast iron. During the war a quantity of work had been done on peeling, annealing ore, and on residual elements, but here was a scientific attempt to estimate the reactions which occurred during annealing. The industry must be very pleased that at last an attempt was being made to put the old whiteheart malleable cast-iron industry on a scientific basis. In one respect he disagreed with the Authors in that he did not like the introduction of the word "whiteheart." Personally, he felt that the line between whiteheart and blackheart was not nearly so sharply defined as it was some 10 years ago. It was to the gaseous annealing process one must look for future development.

The Paper by Jenkins and Williams was qualified by the statement that the results were obtained under certain conditions. His own experience suggested that the rate of rise to temperature was very important, particularly in the case of high manganese/sulphur iron, *i.e.*, with a manganese/sulphur ratio of over 1.7, a rapid rise to temperature usually resulted in large coarse nodules very widely dispersed. This brought him to the point in Mr. Robiette's Paper where he so fascinatingly spoke of diffusion constants and estimated the amount of carbon removal on a time factor. Personally, he could not accept a scientific reasoning in that connection yet, because there were certain factors operating. There was, for instance, composition and size of casting, and by size of casting he referred to the fact that in a very thin casting, cast very hot and chilled very quickly, the austentite-cementite matrix was very evenly interwoven and, as a result, he believed that decarburisation proceeded very rapidly. On the other hand, in the case of a thick casting, and particularly in that section of a thick casting which cooled very slowly, cementite was large and massive and made decarburisation very difficult because such masses were slow to dissolve. From the point of view of estimating the rate of decarburisation, there was the influence of the base iron used in the charge. He mentioned these various points merely as a matter of caution.

In Mr. Robiette's Paper, the cost of producing malleable iron by this process was very low and it was assumed from these results that the figures could be reproduced quite easily. Old-fashioned manufacturers of malleable had, however, a very large safety factor of time in their processes which, to some extent, took care of the many possible variations and he believed that to use the processes described in the Papers very great technical control would be required to achieve the results now put forward in the annealing times stated. The existing specifications had been criticised by Mr. Robiette, who, however, had mentioned he knew they were to be revised. The point was, however, that the manufacturers were controlled by the buyers and the buyers wanted, above all, machinability. As he saw it, machinability was secured by

Gas Annealing of Whiteheart Malleable

reasonably high ductility and elongation figures. In his view, that was the important factor.

Tensile Results Sought

MR. G. R. SHOTTON said he had nothing to say on the Paper by Jenkins and Williams except to congratulate the Authors upon having so rigidly kept down to fundamentals. He also paid a tribute to Mr. Robiette for his very clear exposition of the theory of decarburisation. Although it did not involve any new angle, it was the best explanation he had seen in print so far. The most serious omission from this Paper was the absence of any tensile results. Mr. Robiette explained that to some extent by referring to the inadequacy of the test-bar. On the other hand, he had illustrated castings which had been given a 40-hr. anneal and which were said to be equivalent to commercial annealing. Therefore, it would have been thought possible to anneal test-bars with these castings and obtain test results comparable with the commercial figures obtained on these sections.

In Fig. 12, Mr. Robiette showed a photomicrograph of a casting which had been subjected to diffusion treatment for six hours in a non-carborising atmosphere, and the inference from the Author's text was that the carbon content had more or less levelled out. It did not seem likely that this result could be achieved in the time of six hours, as the carbon gradient would rapidly level out and carbon migration would thereby slow down considerably. There would appear to be an anomaly in Mr. Robiette's remarks in that the impression was given that carbon would diffuse to the skin and level up the carbon concentration more rapidly in a non-decarborising atmosphere than it would do under the ordinary annealing conditions. He suggested to Mr. Robiette that Fig. 12 showing diffusion effect was taken from a fairly heavy section with a high carbon concentration gradient, otherwise there could not have been such a pronounced migration of carbon in the time of six hours. Mr. Robiette was asked to confirm this supposition. He did not consider that a diffusion effect would be so pronounced as was suggested by Mr. Robiette because it was anomolous that the carbon should diffuse in a non-decarborising atmosphere more rapidly than under the decarborising conditions during the original annealing treatment, particularly as carbon gradient would at the same time be rapidly levelling out.

Weaker Gas Mixtures Advocated

MR. P. F. HANCOCK said that, as one who had been closely concerned with the development of gaseous annealing processes, he regarded the Paper by Jenkins and Williams as a very thorough investigation into one aspect only of the subject, and within this limitation, which he believed the Authors themselves fully realised, he thought the Paper was very good.

With regard to the composition of the atmosphere used for annealing, he wondered why the Authors did not use weaker mixtures. In practice, the provision of an adequate flow of decarburising gas over the castings was not always easy, and it was usually important to use as strongly decarburising an atmosphere as possible. He also wondered if the Authors had considered this type of atmosphere from the point of view of the hydrogen content and its effect on the metal being annealed. It had been his experience that certain compositions used for malleable manufacture responded very badly to atmospheres containing a high proportion of hydrogen.

In Table I of the Paper there was a discrepancy which he could not understand. It gave figures for total weight loss and residual carbon content for test-bars of various sections after treatment. He would have expected that for bars of twice the thickness the total weight loss would be approximately doubled for the same residual carbon, but from the figures given this did not appear to be so. For example, comparing the 0.092-in. bar annealed 10 hrs. at 1,050 deg., giving a residual carbon of 0.53 per cent., with the 0.188-in. bar annealed 20 hrs. at 1,050 deg., giving a residual carbon also of 0.53 per cent, the weight loss in the first case was 23.14, and in the second only 31.37, *i.e.*, 30 per cent. or so greater, whereas one would expect it to be nearly doubled. Other similar examples could be found in the Table.

With regard to the effect of temperature, he was rather surprised at the results shown in Fig. 5, where, apparently, increase in temperature from 975 to 1,050 deg. C. had little effect on the rate of decarburisation. This was not in agreement with theoretical diffusion data nor with his own experience. Moreover, it did not appear to be in accordance with the results shown in the Author's own Fig. 6, where there was obviously a big difference between 1,000 and 1,050 deg., particularly on the 10 hours' specimens. He agreed that the rate of solution of cementite was not a controlling factor in the rate of decarburisation at any stage of the anneal, but in the later stages the re-solution of precipitated graphite did become the controlling factor, and rate of decarburisation then, of course, did not depend only on the diffusion constant.

The Paper stated that partially burnt coal gas was a cheap atmosphere for annealing whiteheart malleable, but as Mr. Robiette had pointed out in his Paper, the theoretical figure for coal gas consumption (without recirculation) gave a cost of the order of £2 15s. per ton annealed. And this was probably optimistic as far as practical considerations were concerned, since it was necessary to pass more than the theoretical amount of gas through the furnace to ensure thorough decarburisation throughout the charge, and to have a margin of safety.

Theory Reviewed

MR. JENKINS, mentioning what he termed one or two points of academic interest in connection with the application of standard diffusion laws to the decarburisation of cast iron—discussed in Mr. Robiette's Paper—said that one could not expect, as rightly pointed out, that the established diffusion constants for carbon in austenite could be applied to cast iron, because of various factors, such as composition,

graphitisation, etc. It had been the experience of Mr. Williams and himself, and was brought out in their Paper, that for long-term treatment the relationship between the loss of weight and the time of treatment did not follow a parabolic law. In fact, the time necessary to effect a certain degree of decarburisation was in excess of that based on the parabolic law of diffusion, due almost entirely to the fact that much of the carbon was being lost as a diffusing medium because of graphitisation, and the effect of this was to prolong the time of the anneal. As far as malleability was concerned, however, the slowing-down of the decarburisation process was countered to some extent by graphitisation, and in the long run graphitisation plus decarburisation was better than a prolonged decarburisation process alone, as far as the time of anneal was concerned.

Another point in Mr. Robiette's Paper was in connection with the consideration of the water-gas reaction. It was implied in the Paper that one must assume for purposes of calculation that the annealing atmosphere would first establish equilibrium conditions for this reaction and then react with the carbon in the iron. Personally, he did not think that this really happened, and considered that all the inter-gas and decarburising reactions went on at the same time, but with varying velocities. Early in the Paper Mr. Robiette assumed that the gas in the furnace first reached equilibrium for the water-gas reaction, and he then proceeded to assess the amount of carbon removed by the new concentration of CO_2 and water vapour. If the water-gas reaction proceeded to equilibrium before reaction with the carbon in the castings commenced, it did so by forming more water vapour, and, in his view, water vapour in such atmospheres was a far more active decarburising agent than CO_2. In assessing the decarburising power of an atmosphere, therefore, it is necessary to be careful as to what its composition is in the furnace when it reaches the castings.

With regard to embrittlement in an atmosphere containing hydrogen, cast irons as produced contained appreciable quantities of this gas, either occluded or dissolved in the iron. What the concentration was he did not know, but he believed that a sub-committee had been formed or was in the process of formation, which would supply a great deal of useful information on that point. It was stated by Mr. Robiette that a spongy or porous area was always found in decarburised grey iron. Presumably he was referring to iron castings malleablised in gas because later it was stated that the pores appeared to seal themselves completely in the iron-ore process.

MR. ROBIETTE said he was referring to grey iron; there were always spongy areas in decarburised grey iron.

MR. JENKINS suggested that a more probable explanation of the embrittlement was that the hydrogen which was already present in the iron, either in solution or occluded, would more readily diffuse out into an atmosphere which contained no hydrogen and that the embrittlement, after malleablising in a hydrogen-containing medium, was inherent in the iron itself, due to the retention of the hydrogen originally present. That no embrittlement was obtained on annealing in simple CO/CO_2 mixtures or in the ore process was due to the increased tendency for the hydrogen, already in the iron, to diffuse out into a surrounding atmosphere in which its partial pressure was nil. The fact that it was found only in irons having a manganese/sulphur ratio above 1.7 may be due to the fact that the effect of the hydrogen in high sulphur irons is masked by the retarding action of the sulphur on the degree of graphitisation. Further, the formation of the spongy or porous surfaces which promote the occlusion of hydrogen, with resulting embrittlement, are attributed by the Author to the re-solution of precipitated graphite. Would it not be better, herefore, to anneal the casting at a temperature which would ensure a decarburised zone in which there would be no graphitisation, and confine graphite precipitation to the core?

Finally, with regard to the decarburisation of cast iron, followed by carburisation. It was known that in the carburisation of steel, if decarburising conditions are produced following carburisation, the carbon in the case diffused outwards to the decarburised surface as well as inwards to the core. This tended to build up sharply-marked zones of different carbon content, the boundaries of which, on subsequent heat-treatment, proved to be planes of weakness. He would be glad to know if Mr. Robiette had encountered this effect in his work on the carburisation of malleable iron.

Mr. Robiette's Reply

MR. ROBIETTE, replying to the discussion, and promising a detailed reply in writing, dealt first with the point raised by Mr. Peace with regard to austenitic manganese irons and the possibility of producing graphite. It had been his experience, he said, that a high content of manganese, say 12 to 15 per cent., no graphite was ever formed. As regards sulphur, there was very little sulphur in the iron even if the sulphur in the raw material originally was high because it floated out in the melt as manganese sulphide. Thus there was no question of any manganese/sulphur ratio. It was not correct to say that only ¼-in. austenitic manganese castings were referred to in the Paper as the only ones being made; they had been made up to ¼ in. and 1 in. thick. It was possible to leave some carbide in the core without appreciable effect on the physical properties of the material, which was normally used in compression.

Reference had also been made by Mr. Peace to straight whiteheart malleable and Table II in the Paper where the time of 36 hrs. was given for a ¼-in. section casting, and it was pointed out that this did not agree with the results in the Paper by Jenkins and Williams. There had been some discussion regarding the results given in the latter Paper for decarburisation at higher temperatures and it had been pointed out that their results did not agree with his in regard to the effect of temperature. The 36 hrs. quoted by himself was the time the castings were at the temperature of 1,050 deg. C., but decarburisation also

Gas Annealing of Whiteheart Malleable

took place during both heating and cooling. The table was prepared from results on production castings and that would explain some of the difference. The rest of the difference was probably due to the fact (as opposed to the findings of Jenkins and Williams) that if the temperature was increased from 950 to 1,050 deg. C., the rate of decarburisation was increased by approximately 60 per cent. That agreed with what would be expected from the diffusion law, from which the degree of carburisation was proportional to the square root of the time.

As regards low velocities of gas in tightly packed charges, clearly one could not take two plates of malleable iron and expect to decarburise them uniformly on the surfaces in contact. With most castings, there was only point contact and at points of contact there was no difference at all in the amount of decarburisation. There should be a perfectly active circulation of gas and the more tightly packed the castings the faster must be the flow of recirculated gas. That was the principal thing, and there had never been any difficulty, after experimenting, in adjusting the rate of circulation of the gases to suit particular charges. On the other hand, much could be achieved by suitably selecting the charge and mixing lighter and heavier pieces and increasing the voids.

Continuous Treatment

With regard to continuous treatment, that had been considered, but it was necessary to have a fair output of similar sections of casting because it was not convenient to change the cycle. If there was a fairly large output of similar castings—say 50 to 60 tons per week—a continuous furnace was an advantage.

He had been asked by Mr. Neath whether he could confirm that if the furnace was sealed to prevent any gas leakage, the amount of carbon loss in blackheart would be infinitesimal. That was so if the furnace was very tightly sealed. It was purely a question of furnace design. Theoretically, there was no difficulty whatever, but if the furnace was not so tightly sealed as was wished, it was possible to overcome that by using a non-decarburising gas.

As to the statement in the Paper that increased strength of malleable iron was much better than ductility, in saying that he was only generalising. He had actually stated that "under certain conditions" it was better and one of the conditions where it was not better was when the material was required to be welded after annealing.

As to the effect of residual sulphur in the gases used, normally there was a sulphur content of 1 grain per cub. ft., or less, and that had no effect on the problem of peeling mentioned by Mr. Bernstein. His own reference to peeling related to the atmosphere described in the Paper. No experiments had been carried out to ascertain whether the gas increased in sulphur content after annealing. Theoretically there should be a small increase in H_2S and COS. It would be impossible to produce SO_2 from theoretical considerations.

With regard to the re-circulation of gases, he did not add CO_2, as suggested by Mr. Bernstein. He added air which produced CO_2 and in the case of the process which annealed castings in a self-generating atmosphere there was no hydrogen. In the case of a coal-gas atmosphere a certain proportion of water vapour was necessarily formed as well as CO_2.

In reply to Mr. Dovey's comment as to the peculiarity that these two Papers should have appeared simultaneously, dealing with a similar subject, the fact was that his own Paper could have been largely written in 1942, but the Ministry of Supply imposed a secrecy order on the information regarding the process. It had been found from experience that 1,050 deg. C. was the optimum temperature; that was the result of annealing several tons of castings. Providing the castings were adequately supported and there was not too great a superimposed load, there was no warping even at 1,050 deg. C.

With regard to ¼-in. sections mentioned by Mr. Dovey, actually the time required to decarburise such sections was so short in any case that with the same volume of gas passing through one would only increase the rate of removal of carbon from the surface in the first hour, and seeing that it would take 5 hrs. to heat up and 10 hrs. to cool down, the saving in time by the use of a more decarburising gas at the start of the process would hardly be worth while. It was better to run at one constant mixture from the point of view of simplicity of operation. It was purely a question of gas speed to present the formation of gas pockets.

The point had been raised by Mr. Jenkins that from the tests in the Paper there seemed no difference between the rate of decarburisation with CO_2 and water vapour and that as the limiting factor was the rate of diffusion, carbon could be taken away from the surface at the rate it diffused to the surface. It was pointed out in the Paper that the rate of carbon removal had been estimated from theoretical considerations, but the actual amount of carbon removal per unit of surface areas in his calculations was based on actual tests. He had given a figure which was a test figure, and in that case the rate of carbon removal for certain section, per square inch, was determined, and he had related that, as an example, to a typical charge and showed that there was so much carbon removal in the first hour, and so much in the second hour, and so on. He had been careful to point out that it was not possible to use diffusion law data for absolute determinations. It could only be used comparatively. It might be said that if the time were doubled then there was double the effect. The diffusion law can be applied reasonably accurately for carburisation, but graphitising upsets calculations for malleable iron.

Concerning operating costs, which had been mentioned, he would not have published his figures if they had not been based on practical results, but over a period of about nine months a firm operating the process had confirmed the figure of within £4 and £5 per ton.

In reply to Mr. Shotton and the section referred to in Fig. 12, he said he had not referred to any par-

ticular section and at the moment had not with him the thickness of the section in question, but he would let Mr. Shotton have it. It was all a matter of economics as to how far one should diffuse carbon from the core. In very heavy castings it was easily done, but he did not suggest that it was possible to diffuse carbon to the surface quicker than it was possible to decarburise.

Water-gas Reaction

He entirely disagreed with Mr. Jenkins' comments on the water-gas reaction because even when one bright annealed a piece of steel sheet and kept it in the furnace for five minutes, the water-gas reaction took place, and it was possible to see the effect on the steel sheet by the roughening of the surface, showing that the surface acted as a catalyst. It was his opinion that the water-gas reaction was established in a matter of minutes.

MR. JENKINS interposed that that was satisfactory when dealing with low carbon steel, when the carbon did not enter into the reaction and the effect was catalytic. In this case, it was necessary to consider the possibility of the reaction with the carbon in the iron. His point was that the water-gas reaction did not establish equilibrium first of all. It was necessary to check the other reactions which were going on all the time and which were taking place simultaneously.

MR. ROBIETTE replied that in his opinion, the water-gas reaction was established before decarburisation started. Castings were put into a hot furnace with hot brickwork, etc., but the castings were at room temperature so that there could not be decarburisation and the other reactions could not take place for, say, four hours, and the water-gas reaction could establish itself straightaway.

MR. JENKINS suggested that there were possibly different conditions in other cases than in that dealt with by Mr. Robiette.

MR. ROBIETTE agreed that that might explain the point. As to the view expressed by Mr. Jenkins that H_2O was a better carburising agent than CO_2, he did not think it mattered very much inasmuch as everything was limited by the rate of diffusion of carbon to the surface. There was no difficulty in taking the carbon away, with quite a big range of CO/CO_2 compositions, as fast as it was brought to the surface.

As to the effect of hydrogen, also mentioned by Mr. Jenkins, he himself had only put forward some tentative suggestions in case someone else might have some better ideas, but there was no doubt that if high manganese whiteheart was annealed in an atmosphere which contained an appreciable amount of hydrogen, the results were not as good as doing it in iron ore. The difference was that there was hydrogen in the one gaseous process whereas except in the initial stages there was no hydrogen in the iron-ore process. That had been confirmed by some experiments with hydrogen-free CO/CO_2 mixtures, which showed that the results were the same as in the iron-ore process where there was no hydrogen. How the particular mechanism took place he did not know. He had merely put forward a tentative explanation.

Mr. Jenkins' Reply

MR. JENKINS, in the course of a short reply to the discussion, thanked all those who had taken part in it and said that the remarks made would act as a tonic to Mr. Williams in his present illness.

With regard to the comments by Mr. Peace on Fig. 5, he reiterated that this Paper was more of scientific interest than practical and the upward trend of the curve was certainly of scientific importance. At the same time, he felt it had some practical significance in determining the optimum temperature in gaseous malleablising. With regard to Figs. 6 and 7 and the fact that the specimen after 20 hrs. at 1,000 deg. C., showed a wider ferrite band than after 20 hrs. at 1,050 deg. C., he thought that was entirely due to the fact that graphitisation at 1,000 deg. C. took longer to start than at 1,050 deg. C., so that the decarburisation process was able to proceed at 1,000 deg. C. to a greater degree before being interfered with and slowed-down by graphitisation.

In reply to Mr. Bernstein he said that in all the experiments the specimens were cooled under a positive pressure of gas, *i.e.*, no gas flow, and thus there was no entry of air into the furnace tube at all during cooling.

A point had been well brought out by Mr. Hall with regard to heating up to the annealing temperature. In all cases in the work the specimen was introduced into the cold furnace and heated up with it, because this was a scientific approach to the subject and strictly comparable results were required. It was desired, wherever possible, to start decarburisation at the actual annealing temperature, in order to obtain comparative results. Unfortunately, he had no data of the sulphur content of the gases in the spent annealing atmosphere. Throughout, the Authors used an atmosphere with a concentration of sulphur of three to four grains per 100 cub. ft. Town's gas, as delivered, was used in preparing the controlled atmosphere, and no attempt was made at purification. There was no evidence of peeling on the castings.

Maximum Decarburisation

In reply to Mr. Hancock as to why the Authors had selected their particular gas atmosphere, he said that the main controlling factor in the decarburisation of iron in the malleablising process, was the rate of diffusion of carbon to the surface and it did not need a very high concentration of decarburising gas to satisfy the arrival of carbon atoms at the surface. It was found that maximum decarburisation could be maintained with the mixture used and the Authors held the opinion that with this composition a film of ferrite was formed on the surface of the iron very early in the annealing cycle. From that point of view, for the purpose of this particular investigation, there was no object in increasing the decarburising power of the gas.

Although the effect of increasing temperature upon the degree of decarburisation differed from Mr. Hancock's experience, it was fairly consistently obtained in these experiments. It should be pointed out, however, that the effect is probably related to

Gas Annealing of Whiteheart Malleable

specific compositions, and that, while it applied in this particular case, it might not apply to irons of many other compositions.

As to the discrepancies in Table I mentioned by Mr. Hancock, he pointed out that of the two figures quoted, one referred to the carbon as analysed and the other to the carbon as calculated. Moreover, it was not an easy matter to obtain a representative analysis of malleable iron with large nodules of graphite inside, and he suggested that more reliance should be placed upon the calculated figures in the Table, rather than upon those determined by analysis. When looked at, upon this basis, the discrepancy was not very great. Further, doubling the thickness of the casting and annealing down to a common residual carbon content, should theoretically give twice the loss in carbon per unit area, and not four times as stated by Mr. Hancock.

Mr. Robiette's Written Reply

MR. ROBIETTE, in a further written reply to the discussion, said there were a few points which required amplification. Mr. Neath mentioned that it had been shown by some German work that the atmosphere in an ordinary annealing pot usually consisted of about 70 per cent. CO and 30 per cent. CO_2, and he contended that this showed that the old process was not far behind. The Author would like to point out that the above CO/CO_2 ratio is not the result of design or good operation, but is the chemical equilibrium between figure of the iron oxide-carbon-CO-CO_2 system at annealing temperatures.

In reply to Mr. Dovey, the figure in the appendix for the product $\frac{\rho H_2 \times \rho CO}{\rho H_2O}$ should read 0.163, but the argument that this is well on the decarburising side still remains. Also the expression for the equilibrium constant for equation (3) in terms of the mol fractions should read

$$K = \frac{N_{Fe}}{N_c} \cdot \frac{\rho^3 CO}{\rho CO_2}$$

Dealing further with Mr. Shotton's question regarding diffusion, the thickness of the sample from which the photomicrograph (Fig. 12) was taken was $\frac{1}{4}$" in. The Author would also like to emphasise that during diffusion one is dealing with the migration of carbon in austenite unrestricted by the restraining influence of graphite. He also wished to add that a short diffusion time of, say, 6 hrs. would not completely even out the carbon content, but would only flatten the gradient to the extent that it was possible to bring up the surface carbon to about 0.5 to 0.6 per cent., as shown by the illustration (Fig. 12), thereby giving an eminently useful product.

Mr. Jenkins had asked whether a zoned or banded structure had been experienced after decarburisation, as was sometimes experienced in steels. In the Author's experience this was abnormal in steels, and occurred with high-phosphorus contents. It had not been seen in all the malleable-iron samples treated in this manner. In the record of the verbal discussion it was reported that the Author stated that there was normally a sulphur content in the decarburising gases of 1 grain per cub. ft. This should read 1 grain per 100 cub. ft. The Author also stated that the diffusion law could only be used comparatively, and that if the time were doubled the effect would be doubled This, of course, was incorrect, and what was meant was that if the time of treatment were doubled then the effect of doubling the time could be reasonably predicted from the diffusion law.

HELPING APPRENTICES TO CHOOSE A TRADE

A series of talks designed to assist youths to decide for themselves which trade is likely to offer them the best chances of success in life has been recently introduced into their apprentices' training scheme by Leyland Motors, Limited. Just as nearly every boy's ambition at some time in his young life is to become an engine driver, so boys starting to serve their apprenticeship are often inclined to choose a trade which has at some time appealed to their imagination, but for which they may have little or no aptitude or which may not hold out a very promising future.

For some time past Leyland Motors have to a certain extent countered this tendency by ensuring that before a boy is definitely apprenticed to a trade, he receives a preliminary training of a wide character which will not only enable him to learn something of the potentialities of each trade, but also to allow his instructors to test his aptitude for each. This practice is now being further extended by the inauguration of a series of informal talks under the direction of Mr. V. W. Pilkington, the director of engineering. For each meeting a different trades group will be selected as the subject for discussion, and the company will arrange for a specialist to talk on its scope and future. Afterwards, the meeting will be thrown open for discussion. Each meeting will be attended by all the younger apprentices, so that in due course each boy, before he is definitely apprenticed, will have gained a very fair knowledge of the comparative opportunities which each trade can offer to him.

A Popular Misconception

At the first meeting, held at the beginning of October, the subject chosen was foundry work. The boys were addressed by Mr. W. West, the company's foundry manager, who first of all refuted the popular misconception that foundry work was merely a semi-skilled type of work, consisting of monotonous repetition, but was, on the contrary, a creative trade calling for the highest degree of craftsmanship and initiative. He described how each job presented its own particular problems and how, in overcoming these, the skill and ingenuity of the individual played an important part. His talk was illustrated by a film showing the problems which had arisen in the production of an intricate casting and how, step by step, a different technique had been applied to overcome these until eventually good, sound castings were produced.

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NEWS IN BRIEF

ENFIELD CABLE WORKS, LIMITED, are to take over an old brewery at Cwmavon, near Blaenavon, for plastic work.

PALING METALS, LIMITED, is being wound up voluntarily. Mr. J. E. Hartles, King Edward Buildings, High Street, Solihull, is the liquidator.

THE FRENCH GOVERNMENT has ordered five vessels of a total tonnage of about 30,000 from Swan, Hunter & Wigham Richardson, Limited, Wallsend.

LAUNCHES FROM TYNESIDE during the nine months ended September 30 totalled 49 ships of 154,439 tons, against 51 vessels of 124,916 tons last year.

R. & W. HAWTHORN LESLIE & COMPANY, LIMITED, Newcastle-upon-Tyne, are to engine a 7,600-ton cargo liner ordered from the Burntisland Shipbuilding Company, Limited, by Norwegian owners.

IT WAS REPORTED at a meeting of the Tyne Improvement Commission that inquiries were being made by Metal Industries, Limited, Rosyth, regarding the establishment of a shipbreaking industry at Jarrow.

THE NORTH OF ENGLAND IRONFOUNDERS' ASSOCIATION has drawn the attention of local education authorities to the difficulties being experienced in obtaining a sufficient number of suitable apprentices for the industry.

THE BRITISH IRON & STEEL CORPORATION (SCRAP), LIMITED, and the British Iron & Steel Corporation (Salvage), Limited, will operate from 7, Park Lane, London, W.1, as from November 5, instead of from Steel House, Tothill Street, S.W.1.

A NEW ASSOCIATION—the Wednesbury and Darlaston Manufacturers' Association—has been formed in that part of the Black Country for the purpose of rendering mutual assistance. Mr. F. N. Lloyd, managing director of F. H. Lloyd & Company, Limited, is the president.

THE COMPANIES REGISTRATION OFFICE gives notice that the names of the undermentioned companies have been struck off the register, and such companies are dissolved:—DULCI ELECTRICAL COMPANY, LIMITED, FARR'S ELECTRIC, LIMITED, JAMES & SHAKSPEARE, LIMITED, and OVERTON METALCRAFT, LIMITED.

IN THE QUARTER ended September 30, there were 387 merchant vessels, of 1,496,243 tons gross, under construction in Great Britain and Ireland. These included 241 steamers of steel and 133 motor-ships (132 of steel and ferro-concrete and one of wood and composite). One steamer was of the 25,000-30,000-ton class.

SIXTY CHINESE ENGINEERING POST-GRADUATES who are to be trained in British engineering works, under the scheme arranged by the Federation of British Industries in conjunction with the Chinese Government, were welcomed in London last week by Sir Frank Gill, chairman of the F.B.I. China Committee.

THE OXLEY ENGINEERING COMPANY, LIMITED, proposes at an early date to issue the remaining 100,000 ordinary shares of 5s. each to present holders. The issue is in order to finance the purchase of more up-to-date plant and machinery for both the Oxley Engineering Company and Thomas Dryden & Sons, Limited.

THE DIRECTORS OF Sanbra, Limited, plumbers' brassfounders, etc., of Aston, Birmingham, 6, propose to increase the capital from £125,000 to £175,000. It is intended to offer to shareholders 520,000 ordinary shares of 1s. each at 3s. in the proportion of two new shares for every five shares held. A meeting will be held to consider the proposal early this month.

MR. GEORGE FISHER, managing director of the Leeds Piston Ring & Engineering Company, Limited, who has been studying production methods in Germany on behalf of the Ministry of Aircraft Production, was particularly impressed with the Germans' thoroughness in the use of testing equipment. He said in an interview that the testing equipment used by one small firm was the finest he had ever seen.

AT AN EXTRAORDINARY GENERAL MEETING of N. Greening & Sons, Limited, woven wire manufacturers, Warrington, a special resolution to increase the share capital was carried. It was indicated by the chairman that at an early date 25,000 of the new ordinary shares of £1 each would be offered to existing ordinary shareholders at 20s. per share in the proportion of one new share for every four ordinary shares now held.

THE HARBOROUGH CONSTRUCTION COMPANY, LIMITED, of Market Harborough, Leicestershire, have appointed Mr. Alfred and Mr. John Augstein—formerly of F. & M. Supplies, Limited—as consultants for their foundry supply department. An arrangement has been made for the exchange of technical information between Kalcium, Limited, of Prague, which is controlled by Mr. A. Augstein, and the Harborough concern.

THE SHEEPBRIDGE COAL & IRON COMPANY, LIMITED, has made an offer for control of the Light Production Company, Limited. The offer is for one-half of each holding of 5s. shares at 20s. per share. The directors of Light Production have guaranteed the transfer of at least 51 per cent. Sheepbridge Stokes Centrifugal Castings, Limited, has supplied Light Production with the necessary castings for piston-ring manufacture for many years.

RELEASE OF FACTORIES

The Board of Trade announces that the return to industry of premises requisitioned during the war for storage purposes is to be accelerated. Wherever possible, more factories are to be turned over to production for the home and export markets. Up to September 30 about 138,000,000 sq. ft. of industrial floor space was still held under requisition by Government departments, premises covering about 12,000,000 sq. ft. had been released to industry, and a further 12,000,000 sq. ft. was in process of being released. If disposals depots, labour, and transport are forthcoming, the Government intend to ensure the release of the remaining factory accommodation by the end of 1946.

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PERSONAL

MR. HENRY DANKS, of Stone Road, Uttoxeter, has just retired after 57 years' continuous service with Bamfords, Limited, engineers.

MR. H. E. PRICE, equipment sales manager at Fort Dunlop, has joined the board of the Dunlop Rim & Wheel Company, Limited, Foleshill, Coventry.

WING COMMANDER P. E. GWYER has resumed his duties as managing director of Metal Components, Limited, after six years in the technical branch of the R.A.F.

MR. CYRIL THOMPSON, joint managing director of J. L. Thompson & Sons, Limited, Sunderland shipbuilders, has been released from the R.A.F. and is back with the firm.

MR. A. G. STEWART and MR. W. S. MORRISON, M.P., have joined the board of the United Steel Companies, Limited. Mr. Stewart was recently elected chairman and general managing director of Stewarts and Lloyds, Limited, in succession to Sir Allan Macdiarmid. Mr. W. S. Morrison was Minister for Town and Country Planning in the Coalition Government.

MR. C. W. HUTCHINSON, formerly principal representative of Thos. Firth & John Brown, Limited, in Lancashire, is to succeed MR. OSWALD SEWELL as principal representative of the company in the Birmingham area. Mr. Sewell will continue with the associated company of Firth-Vickers Stainless Steels, Limited, in an advisory capacity for a period. During the war Mr. Hutchinson has undertaken important duties in the commercial organisation of the company in Sheffield.

MR. G. W. LACEY has rejoined British Aluminium, Limited, after being Controller of Light Metals, Ministry of Aircraft Production. He has been appointed general sales manager. MR. G. A. ANDERSON, who has been Deputy Controller of Light Metals, is appointed deputy general sales manager. The following appointments have also been made:—MR. E. A. LANGHAM, sales manager; MR. A. W. LANGHAM, sales planning manager; and MR. H. H. CUNDELL, development manager.

SIR GEORGE LEVESON GOWER has retired from the board of the Lilleshall Company, Limited. He has been a director since 1903, and chairman since 1939. He is followed as chairman by EARL GRANVILLE, who will be the sixth successive member of the Leveson Gower family to hold this office. MR. T. E. FREESTON, J.P., has retired from the post of joint managing director. Mr. Freeston first entered the service of the company 60 years ago. After a period with John Brown & Company, Limited, Sheffield, as steelworks manager, he returned to the Lilleshall Company in 1918 as general manager and became managing director in 1923.

Wills

FARTHING, J. H., of Altrincham, a director of the General Electric Company, Limited £32,969

TAYLOR, ROBERT, of Oldham, formerly managing director of Asa Lees & Company, Limited, textile machinists and ironfounders £154,066

OBITUARY

MR. JAMES HENRY WILSON, chairman and managing director of George Wilson Gas Meters, Limited, Coventry, has died suddenly, in his 65th year.

MR. CHARLES EDWARD FAIRBURN, chief mechanical and electrical engineer of the London Midland & Scottish Railway Company, died suddenly in London on October 12.

MR. A. E. BROWN, a director of Parson, Limited, iron and steel merchants, of Birmingham, died on October 17, at the age of 75. Mr. Brown, who was in charge of the company's scrap department, was well known in the steel trade. He had been a member of the Birmingham Iron Exchange for many years.

MR. HORACE CHARLES JERVIS, manager in Brazil for Henry Rogers, Sons & Company, Limited, Wolverhampton, was taken ill and died while on his way to this country on a business visit. He was well known in the metal trades in South Staffordshire and had been with Henry Rogers, Sons & Company all his working life. He started with the firm at their Wolverhampton offices and was there for many years before going out to Brazil.

CONTRACTS OPEN

Any date given is the latest on which tenders will be accepted. The address is that from which forms of tender may be obtained.

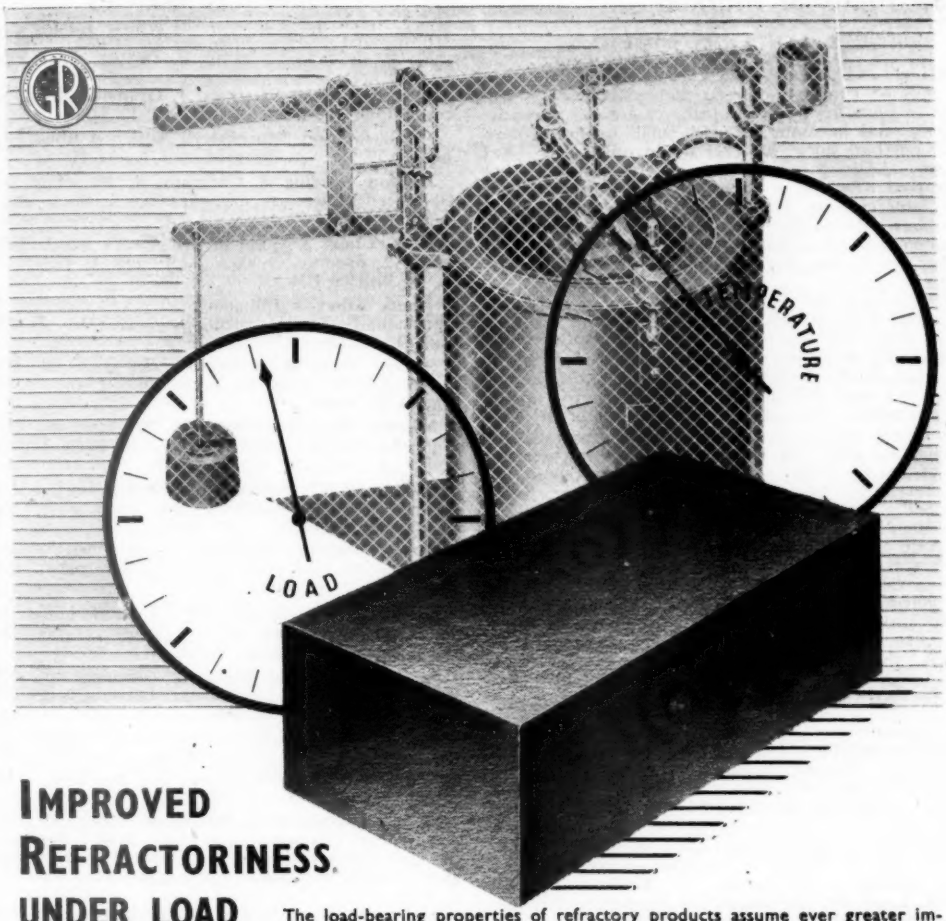
Atcham, November 9—Supplying and laying 540 yds. of 3-in. dia. cast-iron water main, for the Rural District Council. The Surveyor, 24, St. John's Hill, Shrewsbury.

Bakewell, November 10—Provision, laying and jointing of 600 yds. of 5-in. and 3-in. iron pipes, etc., together with construction of pumphouse and collection of underground water, for the Rural District Council. Brady & Partington, Chapel-en-le-Frith. (Fee £5, returnable.)

Bournemouth, November 8—Heavy pattern cast-iron gratings for landing-stage decking, for the Town Council. The Borough Engineer, Town Hall, Bournemouth.

EXAMINATIONS IN FOUNDRY PRACTICE AND PATTERNMAKING

The revised regulations and syllabus for patternmaking and foundry practice, just issued by the City and Guilds of London Institute, are of major importance, because, following the recommendations made by the Institute's Advisory Committee in conjunction with the Institute of British Foundrymen, there are outstanding changes. For the first time, a syllabus for an advanced examination in foundry practice is included—the culmination of an effort strenuously sponsored by the education committee of the Institute of British Foundrymen ever since the establishment of this national examination. The prospectus is available to our readers on application to the City and Guilds of London Institute, 31, Brechin Place, South Kensington, London, S.W.7.



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188

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Raw Material Markets

IRON AND STEEL

Labour and fuel difficulties are restrictive influences on pig-iron consumption. At the moment, coke supplies to foundries and blast furnaces are proving satisfactory, and in some instances small quantities have been put into stock; but fuel would prove a problem if any large expansion of pig-iron output were attempted. Expansion of output at foundries engaged on light castings is hampered by a shortage of moulders. No difficulty is being experienced in obtaining low-phosphorus, refined or hematite iron, except that licences for hematite are not easily obtainable.

The demand for light and heavy scrap continues on steady lines, if only as a result of shrinking supplies. Light cast-iron scrap is coming forward, but good-quality machinery cast iron is not easily obtained. All classes of semi-finished steel are encountering heavy pressure, with the strongest demand for square and flat billets. The expansion in the output of sheet bars has, to some extent, met the urgent requirements of the sheet mills, but only at the expense of users of square and flat billets. To meet the current needs of the sheet mills, large tonnages of sheet bars are being provided.

Substantial rolling programmes are reported from the plate mills. Sheet makers remain extremely busy, and are booked up until the second quarter of 1946. The most heavy demand is for light sheets, both black and galvanised. Tinplate production has fallen short of the weekly average output. Order-books are, to a great extent, full, with most makers not anxious to increase their commitments.

NON-FERROUS METALS

In normal times, no doubt, the non-ferrous metals industry would be enjoying a brisk trade at this time of the year. Instead, potential activity is held up by labour and other difficulties. It is to be hoped that a brighter outlook will prevail in the not too distant future.

This week, a representative from the United States is being sent to Malaya in an effort to uncover additional sources of tin supply. A statement by the Federal Economic Administration announces that the first shipment of tin is expected to arrive shortly in the U.S.A. The shipment, however, is not expected to be large.

Among the interesting statistics issued by the British Iron and Steel Federation are those concerning nickel consumption in this country. The peak of nickel consumption was reached in 1941, when no less than 17,880 tons was consumed. In Canada, nickel production during 1944 was 122,588 tons, compared with 128,579 tons for the previous year.

MR. JOHN HOLLAND, foreman moulder employed by A. Ballantine & Sons, Limited, New Grange Foundry, Bo'ness, died on October 20.

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Diamond Metal Pressings, 1, Granville Road, Newcastle-upon-Tyne, 2—£50,000. G. L. Hodgson.

C. H. Johnson (Machinery), Adswood Road, Stockport—£50,000. A. Johnson and J. A. Hartley.

Jackson Harding & Company, 1, Brandling Street, Gateshead—Engineers, etc. £1,000. R. Booth and M. Smith.

T. R. Gaunt & Company, St. Paul's Road, Birkenhead—Engineers. £1,000. T. R. and E. Gaunt, and T. O. Pritchard.

Frank Allart & Company, 36, Cannon Street, Birmingham, 2—Brassfounders, etc. £5,000. F. Allart and O. Collins.

Sydney Nott & Company, 7, Highland Road, Bromley—Mechanical engineers, etc. £5,000. J. G. S. and G. E. Nott.

Mitchell Bros. (Steelwork), 10, Nursery Lane, Forest Gate, London, E.7—£6,000. V. L. and P. W. Mitchell, and V. R. Drake.

Aylware, 146, Bishopsgate, London, E.C.2—Manufacturers of and dealers in aluminium ware, metal goods, etc. £2,000.

Robert Stuart (London), 215, High Street, Hounslow—Precision and general engineers, metal workers, etc. £3,000.

W. H. Colt (Engineers), 527, Grand Buildings, Trafalgar Square, London, W.C.2—£8,000. J. B. Gledhill and D. W. Setterington.

A. & L. Thomas Engineers (Birmingham), 1041, Warwick Road, Solihull, near Birmingham—£500. C. R. and A. P. L. Thomas.

Taylors (Lancashire)—Engineers, etc. £500. R. Worsley, N. P. Howarth, J. D. P. Ashworth, and E. Warburton, 17, Woodlands Avenue, Peel Green, Manchester.

M. R. Crawford & Co. (Glasgow), Hillington Industrial Estate, Glasgow—Iron, steel, brass, aluminium, and other metal founders. £6,000. J. P. W. and M. S. R. Waddell and O. L. Dunley.

NO PURCHASE TAX ON STOVES & GRATES

By Resolution of the House of Commons, the following goods are to be exempted from Purchase Tax: (1) Domestic cooking, space heating and water heating appliances of the following descriptions:—Stoves, grates, ranges and fireplaces; boiling rings, grillers and hot plates; radiators and convectors; instantaneous water heaters, immersion water heaters and storage water heaters; wash boilers and wash coppers. (2) Parts of such stoves, grates, ranges and fireplaces.

The changes take effect as from October 24, and all traders registered under the Purchase Tax, who are affected by the changes, have been advised accordingly.